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FEDERAL COMMUNICATIONS COMMISSION
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telephone users without unduly restricting legitimate use of scanning receivers.¹

2. This proceeding does not have any direct bearing on the Amateur Radio Service, nor with bona fide use of radio transmitting or receiving equipment by licensed amateur radio operators, with but one possible exception. The League is concerned that the proposed rules (specifically proposed Section 15.121, which references "scanning receivers and frequency converters used with scanning receivers") could be interpreted to restrict receiving converters legitimately intended for use with amateur transceivers, and for routine operation in the Amateur Radio Service in the band 902-928 MHz.

3. Such receiving converters incorporate reasonably broad bandwidth circuitry, and typically are used to translate frequencies in the 902-928 MHz amateur allocation to frequencies in lower bands such as 144-148 MHz. There is a small percentage difference between 902 MHz at the bottom of the amateur band and 894 MHz at the top of the 869-894 MHz domestic cellular band. The nature of broadband receiving converters is that some frequencies outside their nominal bandwidth, albeit attenuated, could conceivably be translated along with the frequencies of interest. This is an inherent characteristic of a broadband converter which would receive frequencies throughout the 902-928 MHz band, owing to the characteristics of practical filters. However, it does not

¹ See the Notice, at Paragraph 1.

necessarily follow that the receiver following the receiving converter would actually tune to the frequencies to which the cellular telephone signals were translated; in the case of amateur radio converters for 902-928 MHz, the clear function thereof is for amateur radio communications.²

4. It is understood that the Commission has no intention in this proceeding of restricting legitimate amateur radio operation at 902-928 MHz, and the League's concern herein is simply to guard against an overbroad interpretation of the proposed rule. However, the rule deserves some clarification to assure that amateur access to the 902-928 MHz band is not unintentionally restricted by the unavailability of converter equipment. Accordingly, the League requests that the proposed Section 15.121 be modified by adding the following sentence at the end thereof:

Receiving converters designed for use by Commission licensees on frequency bands allocated for their use above 900 MHz shall not be deemed "capable of operating or readily being altered by the user" to operate within the Domestic Public Cellular Telecommunications Service.

Therefore, the foregoing considered, the American Radio Relay League, Incorporated respectfully requests that any Report and Order adopted by the Commission in this proceeding incorporate the

² A circuit of the nature that gives rise to the League's concern appears in an article beginning on page 25 of July 1991 QST. Examination of that circuit clearly demonstrates that the unit is not intended to be used for interception of cellular telephone communications. Other circuits used by radio amateurs for the same purpose are similar. A copy of the QST article is attached hereto as Exhibit A.

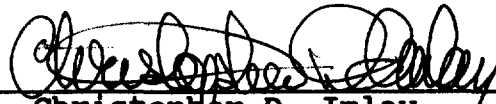
recommended modification, to avoid prohibiting unintentionally bona fide amateur radio equipment used by amateur radio licensees in the 902-928 MHz allocation.

Respectfully submitted,

**THE AMERICAN RADIO RELAY
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A Single-Board, No-Tune 902-MHz Transverter

Using printed band-pass filters, monolithic microwave integrated circuits and an on-board local oscillator, this inexpensive transverter brings new ease to 33-centimeter operation.

By Rick Campbell, KK7B

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The sole obstacle many amateurs face to getting on the UHF and microwave bands is a lack of equipment. It's not that the equipment and antennas for these bands are expensive or unobtainable; it's more that many would-be microwavers feel intimidated by the prospect of building their own gear for these bands. If you have a 2-meter multimode transceiver, you're already well along in getting on the 902-MHz and higher bands. The complete 902-MHz transverter I'll describe here is printed on a single 5- × 7-inch G10 circuit board and costs less than \$150 to build. You'll soon

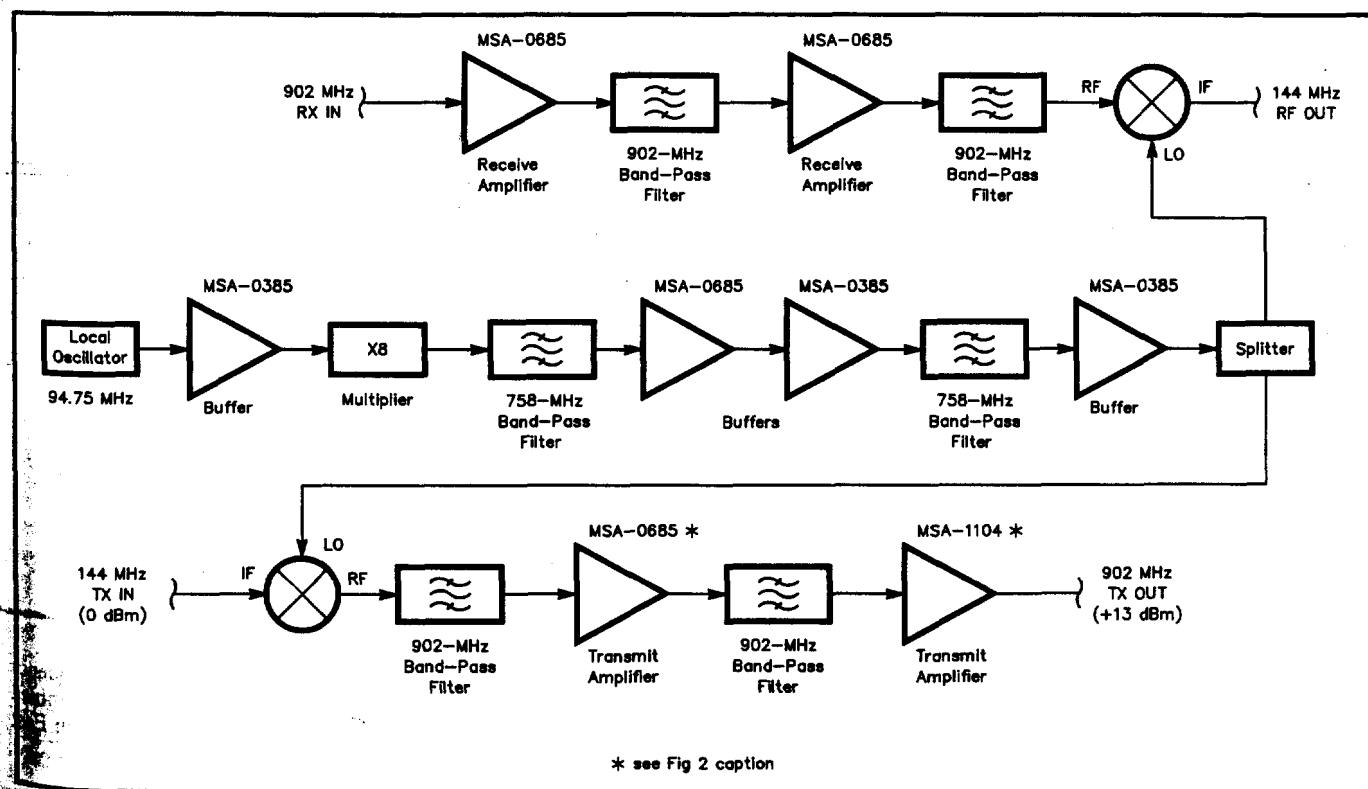
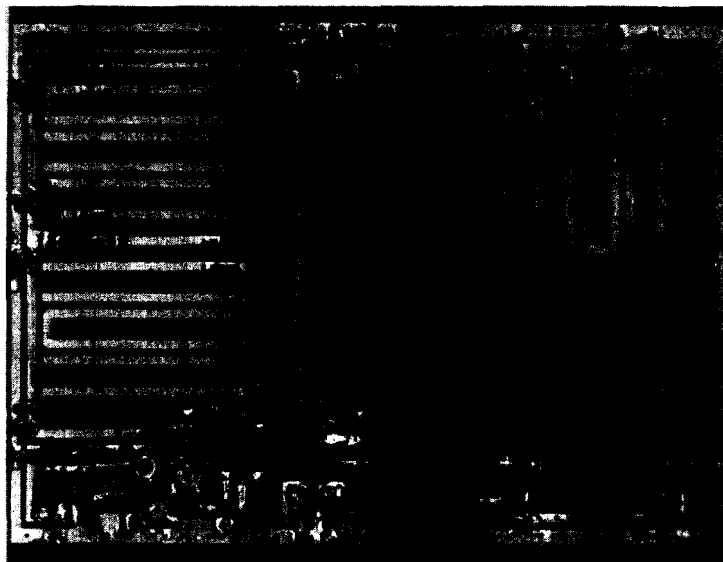


Fig 1—Block diagram of the single-board 902-MHz transverter. Unlike similar designs for the higher bands, this unit has an on-board local oscillator and discrete mixers. The only external connections are for the IF transceiver, antenna and power supply.

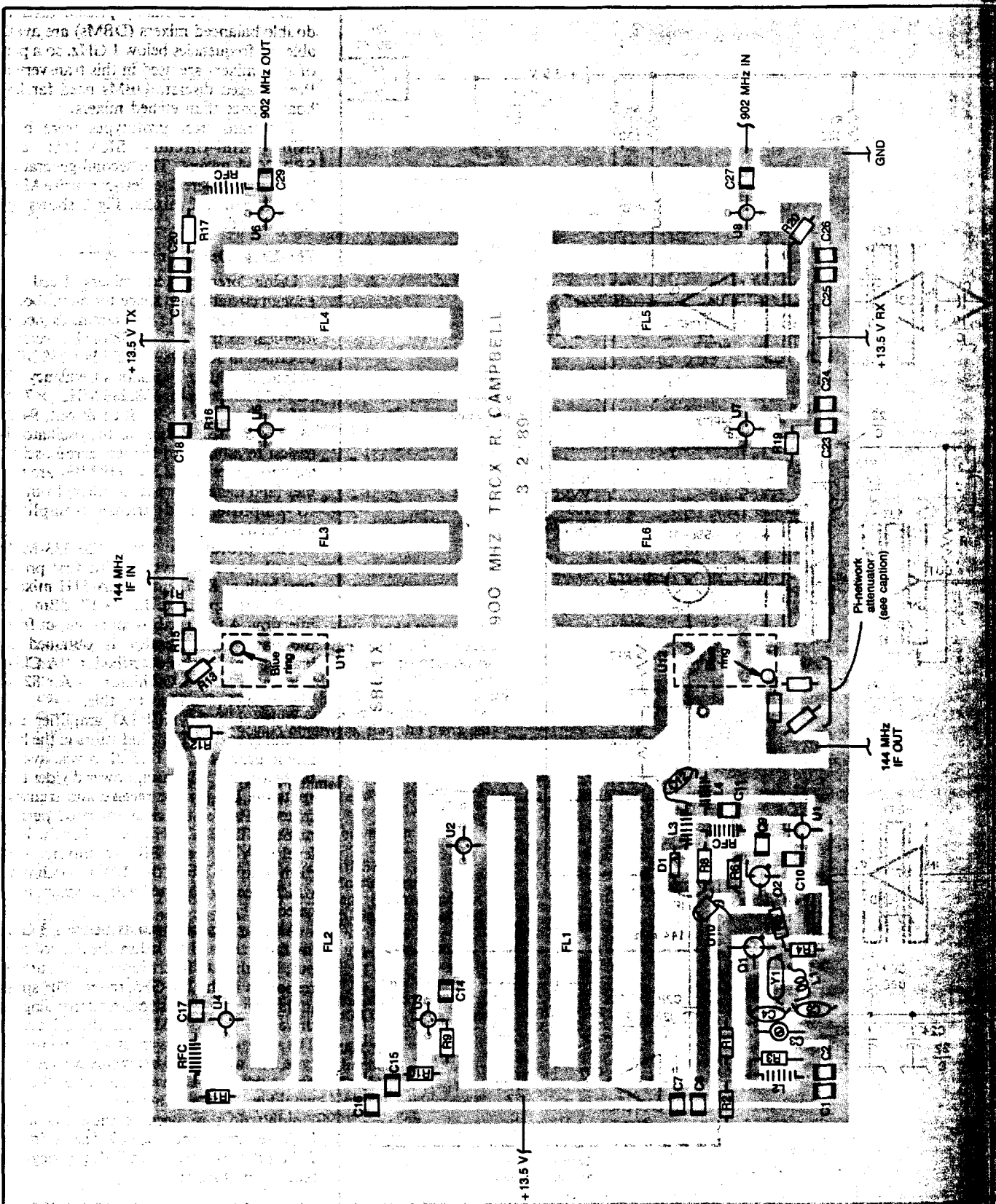


Fig 3—Part-placement diagram for the transverter. Although either MCL or Avantek MMICs are acceptable for use in this project, the MMICs shown here are marked like MCL parts (the colored dot signifies the input lead).

One of the main reasons for using MMICs in this project is their high power handling capability. The MMICs shown here are rated for 100 watts, which is more than enough for this project. The MMICs are also very compact, which makes them ideal for use in a small project like this one.

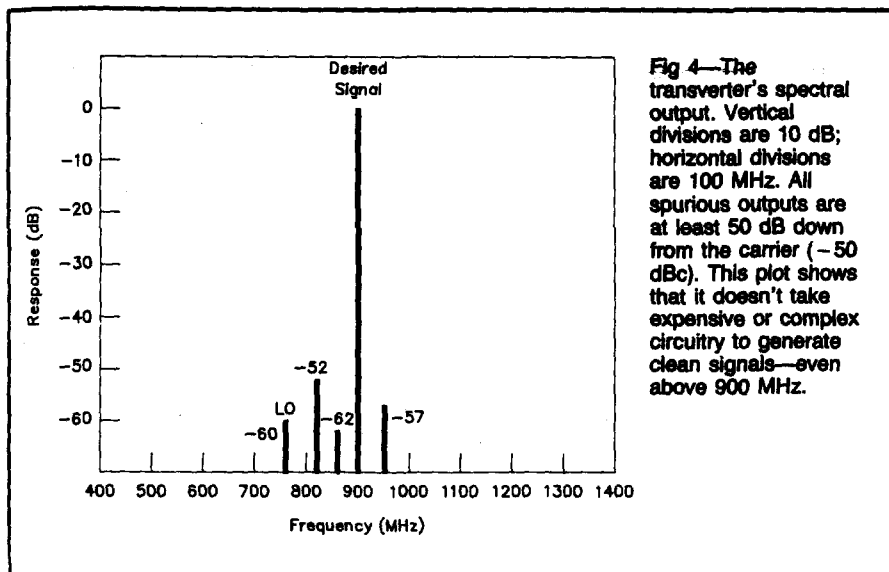


Fig 4—The transverter's spectral output. Vertical divisions are 10 dB; horizontal divisions are 100 MHz. All spurious outputs are at least 50 dB down from the carrier (-50 dBc). This plot shows that it doesn't take expensive or complex circuitry to generate clean signals—even above 900 MHz.

gain (including filter and mixer loss), and a stable 50- Ω termination for an external GaAsFET preamplifier.

The first prototypes used an MSA-0685 IF amplifier after the receiver mixer, but total gain was excessive. The SBL-1X version uses a 3-dB resistive pad at the receiver IF port to keep the receive-converter output to an appropriate level.

The transmit amplifier provides 13 dBm (20 mW) output at the 1-dB compression point. This is appropriate for driving a discrete amplifier chain, or for direct connection to the antenna for local, line-of-sight or hilltop operation. Most hybrid linear-amplifier modules suitable for 33-cm use, such as the MC5874 and M67769,¹⁰ require a lower drive level. Fig 2 and the parts list specify components for versions with 13 dBm (20 mW) output and with 0 dBm (1 mW) output to best suit your requirements.

Construction, Tuning and Operation

Because of the tight dimensional tolerances required for etched microwave filters that require no adjustments, and because there are many variables in the QST printing process, a PC-board etching pattern is not included with this article. If you want to make a board for your own use, send an SASE to the ARRL Technical Department Secretary for a dimensioned copy of the artwork.¹¹ PC boards, parts and kits are available, however, as mentioned earlier.¹² Follow the construction guidelines discussed in Jim Davey's 1989 article,¹³ and use only high-quality, microwave-rated porcelain chip capacitors in building the circuit.

Avantek and Mini-Circuits (MCL) make MMICs suitable for use in this project. See the parts list in the Fig 2 caption for equivalent parts. There is some variation in the packaging of MMICs. Some use a colored dot at the bevel-cut input lead; others use a raised dot at the output lead. Be sure to install the MMICs in the correct orientation.

Fig 3 shows placement of parts on the transverter PC board. The 144-MHz IF out-

put comes off the board via a pad adjacent to U12. If necessary, you can use the traces in that area for a pi-network attenuator, or as a take-off point for the receiver signal or for a subsequent amplifier stage, such as the boxed section in the lower right corner of Fig 2.

Once the PC board is populated, the only adjustment this transverter requires is tweaking of its LO trimmer (C3) to ensure reliable oscillator starting. To do this, apply 13.5 V to the LO. If you can, observe the LO signal at 758 MHz and adjust the trimmer until the oscillator restarts every time power is removed and reapplied. If you like, you can also use either the 902-MHz transmit or receive section to verify this. The 94.75-MHz LO is also audible on standard FM-broadcast receivers. In operation, apply 13.5 V to the LO and the transmit or receive section, depending on which is in use. (It's good practice to remove power from the unused stage.)

Performance

When driven with 1 mW of 144-MHz RF, this transverter provides a clean, low-power 902-MHz signal. All spurious outputs are more than 50 dB below the desired output, as shown in Fig 4. The transmit-converter output is suitable for direct connection to a linear amplifier without additional filtering.

On receive, the transverter's under-4-dB noise figure and unconditionally stable 50- Ω input termination are hard to beat. Image rejection is more than 70 dB. No input filtering is done before the first amplifier stage, so the input stage is susceptible to overload in high-RF environments. For use in such environments, there are several options:

- Replace the receive amplifiers with MSA-1104s. This increases the noise figure by about 1 dB and increases dynamic range by about 10 dB. This is usually not enough of an improvement to cure overload, though.

- Omit the first amplifier stage. This increases the noise figure to 7 or 8 dB, but

will probably cure the problem.

- The best alternative: Use an external low-loss filter. If this or any other transverter is to be used around other transmitters, it is good practice to use a low-loss cavity filter before the first receive-amplifier stage.

Conclusions

When used with a suitable outboard linear amplifier and a GaAsFET preamp, this transverter easily outperforms older designs—at a fraction of the cost. The performance advantages gained by the use of printed band-pass filters, combined with the elimination of all microwave adjustments and the need for a spectrum analyzer, are significant advances in the state of the art that are common to this family of microwave transverters.

When this transverter is coupled with the right antenna system, you can work tremendous DX on the 902-MHz band. Dave (WA3JUF) Mascaro's QST article, "A High-Performance UHF and Microwave System Primer," which begins on page 30 of May 1991 QST, has antenna ideas and lots of other useful information on how to get the most out of your UHF station.

Acknowledgment

Thanks to Don Hilliard, WØPW, for building and testing a prototype, and for preparing the schematic.

Notes

¹R. Campbell, "A Single Board No-Tuning 23 cm Transverter," *Proceedings of the 23rd Conference of the Central States VHF Society* (Newington: ARRL, 1989), pp 44-52. This book is available from ARRL for \$12 (plus \$2.50 postage and handling, or \$3.50 for UPS or insured parcel post), or from your local dealer.

²J. Davey, "No-Tune Transverter for 2304 MHz," *Proceedings of Microwave Update '89* (Newington: ARRL, 1989), pp 30-34. See note 1 for ordering information.

³J. Davey, "A No-Tune Transverter for 3456 MHz," QST, Jun 1989, pp 21-26. Also see Feedback, Oct 1990 QST, p 31.

⁴R. Campbell, "A Single-Board Bilateral 5760-MHz Transverter," QST, Oct 1990, pp 27-31. This article lists, in its end notes, sources for lots of information on microwave antennas and other subjects of general interest.

⁵Etched PC boards, crystals, kits of parts, assembled boards and complete transverters are available for this rig and the projects referenced in notes 1-4 and 7, from Down East Microwave, RR 1 Box 2310, Troy, ME 04987, tel 207-948-3741, fax 207-948-5157. Catalog available.

⁶See note 1.

⁷R. Campbell, "A Clean, Low Cost Microwave Local Oscillator," QST, Jul 1989, pp 18-23.

⁸See note 7.

⁹R. Campbell, "A Clean Microwave Local Oscillator," *Proceedings of the 1296 and 2304 Conference*, reprinted in *Proceedings of the 21st Conference of the Central States VHF Society* (Newington: ARRL, 1987), pp 51-57. See note 1 for ordering information.

¹⁰Down East Microwave (see note 5) carries these hybrid amplifier modules.

¹¹Send a no. 10 SAE with one unit of First-Class postage to the ARRL Technical Department Secretary; request the July 1991 QST 902-MHz transverter template package. The PC-board artwork is copyrighted by Down East Microwave. Feel free to use it to make boards for your personal, noncommercial use, but not for commercial purposes.

¹²See note 5.

¹³See note 3.